A HIGHWAY CORRIDOR PLANNING PROCESS FOR NEPA COMPLIANCE USING QUANTM

Goose Creek Bypass Case Study

Co-Authors – Dale Anderson, Len Bettess, Karen Comings, Trevor Howard, and Jason Brinkman (1)

April 2005

(1) Respectively, Vice President – Environmental / Water Resources, Entranco Inc.; Manager, Business Development & Engineering – Americas - Quantm, Inc.; Environmental Engineer, Entranco Inc.; Project Manager, Entranco Inc.; and Senior Project Manager, Idaho Transportation Department

ABSTRACT

In this paper, we provide an overview of the efforts undertaken to plan a new highway segment that would bypass Goose Creek Canyon. As part of our planning process, we screened alternatives and used the Quantm System to simultaneously analyze complex engineering and environmental issues for highway corridor analysis. The alternatives our team considered include upgrading the existing highway or providing a new, four- to seven-mile route to improve safety on SH 55, between the towns of New Meadows and McCall, Idaho.

Our highway planning effort recognized the challenges of evaluating multiple highway alternatives for to comply with the NEPA process requirements. To meet these challenges, the Idaho Department of Transportation (ITD) and Entranco partnered with Quantm to conduct the project. Quantm provides a highway planning computer-based optimization tool and staff support to locate project alternatives that meet pre-determined engineering and environmental criteria. To establish a process for alternative screening, our team combined Entranco's experience in complying with NEPA in Idaho and the unique abilities of the Quantm system. GIS technology and Quantm were used together to define and evaluate highway alternatives. ITD and Entranco used Quantm to screen alternatives and select highway corridors for further NEPA evaluation. In doing so, we developed a process to screen alternatives that addresses the challenges for determining new highway corridor alternatives. The end-objective of this process is compliance with NEPA as documented in an Environmental Assessment or Environmental Impact Statement to provide clearances for transportation improvements.

This paper has been prepared as a handout for the ITD Design Conference. The text is based primarily on a project report prepared by Entranco for ITD on the Goose Creek Grade Bypass Study. The project report is on file at ITD and contains more details on the alternatives analysis produced using Quantm.

Questions about this paper should be directed to:

Dale E. Anderson -Vice President – Environmental / Water Resources
Entranco, Inc.
10900 NE 8th Street Suite 300
Bellevue, WA 98004

Questions about the use of Quantm should be directed to:

Leonard Bettess
Manager, Business Development & Engineering - Americas –
Quantm, Inc.

2544 Kinnard Avenue
Henderson, NV 89074

What are our presentation objectives?

The purpose of our presentation and paper is to:

- Discuss the challenges of highway corridor planning in Idaho as it relates to the ITD environmental process, using the Goose Creek Grade Bypass project as a case study.
- Describe our project approach using Quantm and GIS technologies to establish highway corridors and select alternatives that comply with the requirements of the National Environmental Policy Act (NEPA).

Where is the project and what is its purpose?

The project is located on SH 55 in central Idaho, about 100 miles north of the City of Boise. The Goose Creek Canyon Grade, a steep, sharp-curved roadway, connects the towns of McCall and New Meadows.

The purpose of the project is to construct a safe, economical, and environmentally acceptable highway around Goose Creek Canyon.

Bypassing Goose Creek Canyon would avoid many physical problems including: narrow 22-foot wide roadway, steep 7 percent grades, shaded areas due to lack of sun exposure that can lead to frequent icing conditions in winter, poor curvature, low driving speeds, and inadequate passing opportunities.

What are the challenges of the highway environmental process?

Entranco staff have spent the last 10 years assisting ITD in achieving environmental compliance on highway projects. This work involves compliance with the NEPA and the Endangered Species Act (ESA) and other federal and state regulations. All of our ITD experience has involved highway corridor and alternatives analysis, and working with stakeholders, including citizens, and regulatory agencies.

For several of our recent projects, we have advocated that ITD and stakeholders agree on a basic decision process (figure 1) to help move the project forward. The decision process includes working with ITD and the stakeholders to establish why we need the project, evaluating and screening highway alternatives, and deciding which alternative should be selected for further evaluation. Following this process keeps the team focused on meeting the challenges of NEPA compliance.

Some of the challenges we've faced during this process include:

- How to deal with previously studied highway alternatives?
- How to evaluate the existing highway upgrade comparably to new highway alternatives?
- How to consider other highway alternatives with dollar and time limitations?
- How to gain the trust and confidence of the citizens that your work is objective?
- How to gain the trust of and effectively work with resource agencies?
- How to obtain concurrence on a screening process with stakeholders?
- How to agree on how much data are enough to make a screening decision?
- How to advance the project in light of politics, policy changes, and turnover of team members?

Most of our ITD NEPA experience has involved preparing Environmental Assessments (EA). The choice of an EA has been driven by two key factors: the perception that an EA is quicker to prepare and is less expensive to produce than an Environmental Impact Statement (EIS). This trend may be changing in light of recent legal challenges on ITD highway projects. The pros and cons of the type of NEPA document to use is a topic for other conferences and papers; however, the relevant point for this discussion is how to effectively meet a key challenge of the environmental process—alternatives analysis and deciding how to pick a preferred alternative.

When you use Quantm in the decision process (figure 1), as described below, you avail your team of several advantages to help address many of these challenges.

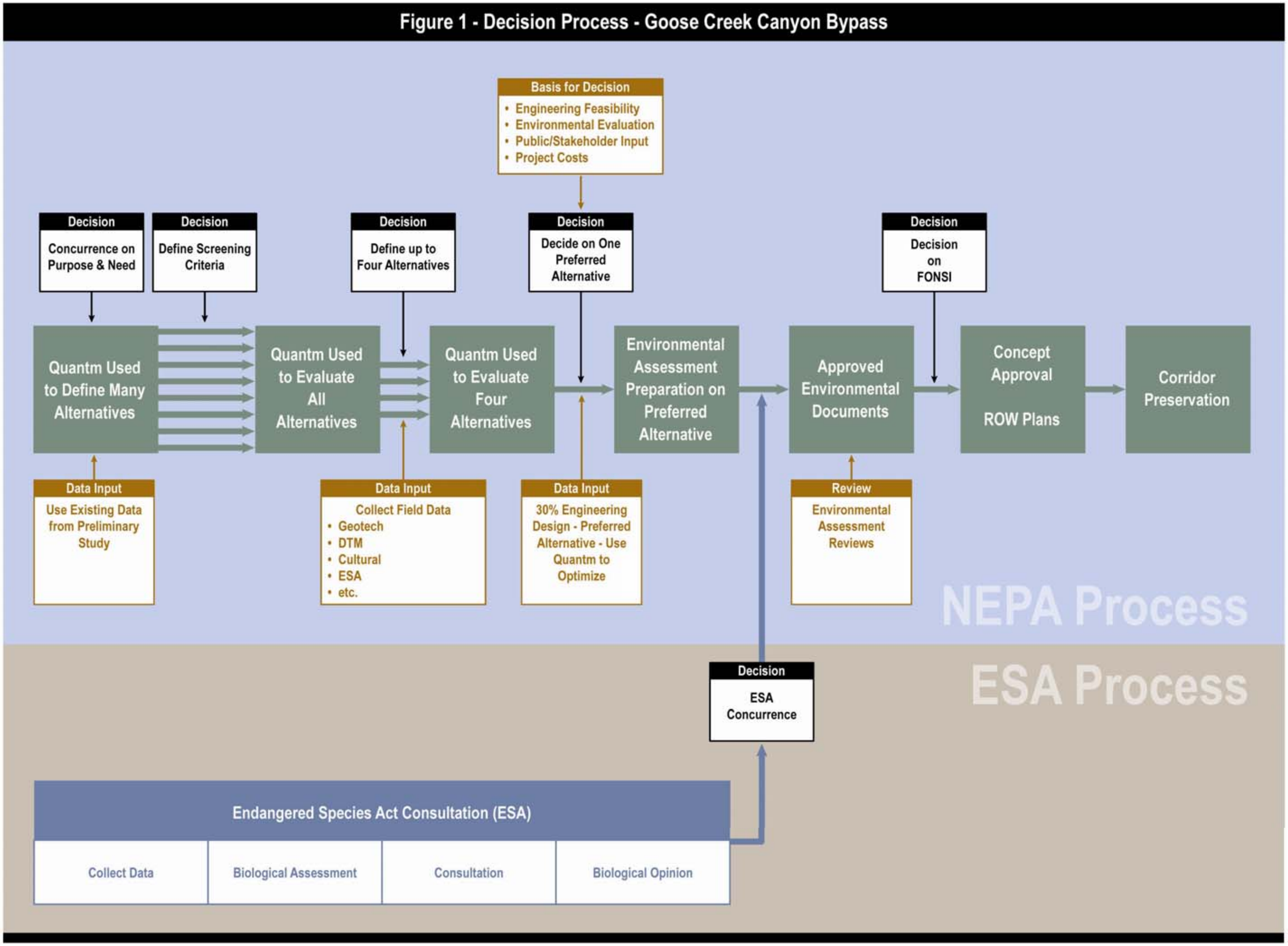
Figure 1 - Decision Process - Goose Creek Canyon Bypass
Basis for Decision
• Engineering Feasibility
• Environmental Evaluation
• Public/Stakeholder Input
• Project Costs
Decision
Concurrence on Purpose & Need
Decision
Define Screening Criteria
Decision
Define up to Four Alternatives
Decision
Decide on One Preferred Alternative
Decision
Decision on FONSI
Quantm Used to Define Many Alternatives
Quantm Used to Evaluate All Alternatives
Quantm Used to Evaluate Four Alternatives
Environmental Assessment Preparation on Preferred Alternative
Approved Environmental Documents
Concept Approval
ROW Plans
Corridor Preservation
Data Input
Use Existing Data from Preliminary Study
Data Input
Collect Field Data
• Geotech
• DTM
• Cultural
• ESA
• etc.
Data Input
30% Engineering Design - Preferred Alternative - Use Quantm to Optimize
Review
Environmental Assessment Reviews
NEPA Process
ESA Process
Decision
ESA Concurrence
Endangered Species Act Consultation (ESA)
Collect Data
Biological Assessment
Consultation
Biological Opinion

What is the basic concept of Quantm?

The current conventional practice for determining highway alternatives essentially follows a manual process. The highway designer/planner uses professional judgment and experience in selecting alternatives that appears to the trained eye to provide the best terrain fit. This process is labor-intensive and, for this reason usually, only a limited number of alternatives will be considered for any project.

For the Goose Creek Grade Bypass Study, our team used a new approach and partnered with Quantm to provide our analysis tool. Quantm provides a highway planning; computer-based optimization tool and staff support to locate project alternatives that meet predetermined engineering and environmental criteria. The Quantm system defines and evaluates highway alternatives and uses these alternatives to establish corridors for further study. ITD and Entranco used this tool to develop baseline alternatives and help screen the alternatives to a set that met established criteria. We planned to select two corridors for further review in a NEPA Environmental Assessment.

The Quantm system simultaneously optimizes the horizontal and vertical alignment to deliver a range of alternatives that meet the engineering, social, and environmental criteria defined by the team. Based on these criteria, the system investigates millions of options for each scenario (various sets of constraints and costs) before delivering a range of alternatives to the team for consideration.

Using the Quantm system, multiple alternatives can be developed in a relatively short time for the team's consideration by the planner. The planner inputs all relevant data using the front-end system, Quantm Integrator. These data include terrain model (DEM or other elevation model), geology (location of various rock types and the cost of earthworks functions within them), design constraints and parameters (road width, minimum curvatures, maximum grades, start and end points, etc.), physical constraints (locations of lakes, streams, urban centers, etc.), and environmental factors (location of wetlands, protected habitats, etc.). This information is then sent to the optimization engine, Quantm Pathfinder in Australia, which simultaneously considers all these factors and generates multiple alternatives.

Quantm endeavors to meet the engineering and environmental criteria before optimizing the alternatives on a cost-basis. The speed and operation of the system supports an iterative process whereby new constraints can be added to determine the location and cost impact of new avoidance zones or changes to engineering criteria. While cost drives the Quantm optimization, it delivers a range of alternatives to enable the team, who has local knowledge and experience, to determine the best alternative.

How was Quantm applied to the Goose Creek Grade Bypass Study?

After completing a three-day training program, the team met for a two-day workshop. This workshop focused on using Quantm to determine preliminary alternatives and establish preliminary corridors for the Goose Creek Grade Bypass (Goose Creek) project.

The Quantm work session was initiated by determining location of project end points and discussing available data. The start point was sited along the existing SR 55 just east of "the Little Ski Hill." The end point was sited along the existing SR 55 between the towns of Meadows and New Meadows.

Engineering and preliminary environmental data were provided to Quantm in GIS format. Table 1 lists the data that was input to Quantm to generate the Goose Creek Bypass Project alternatives. To screen the alternatives and establish highway corridors, the system considered the higher priority environmental considerations reflected in the data: wetlands, Northern Idaho ground squirrel habitat, and known cultural sites.

Table 1
Data Used With Quantm

Linear Features	Roads, Railroads, Utility Network (power lines and power transfer stations), Streams, Nordic and Snowmobile Trails
Special Zones	Wetlands, Lakes, Northern Idaho ground squirrel habitat (surveys from the recovery team field work), bald eagle habitat, cultural areas, public land, Section 4(f) recreational property and historic property, private land, and land use
Additional Data	Geologic Zones

Figure 2 shows the engineering criteria for the project.

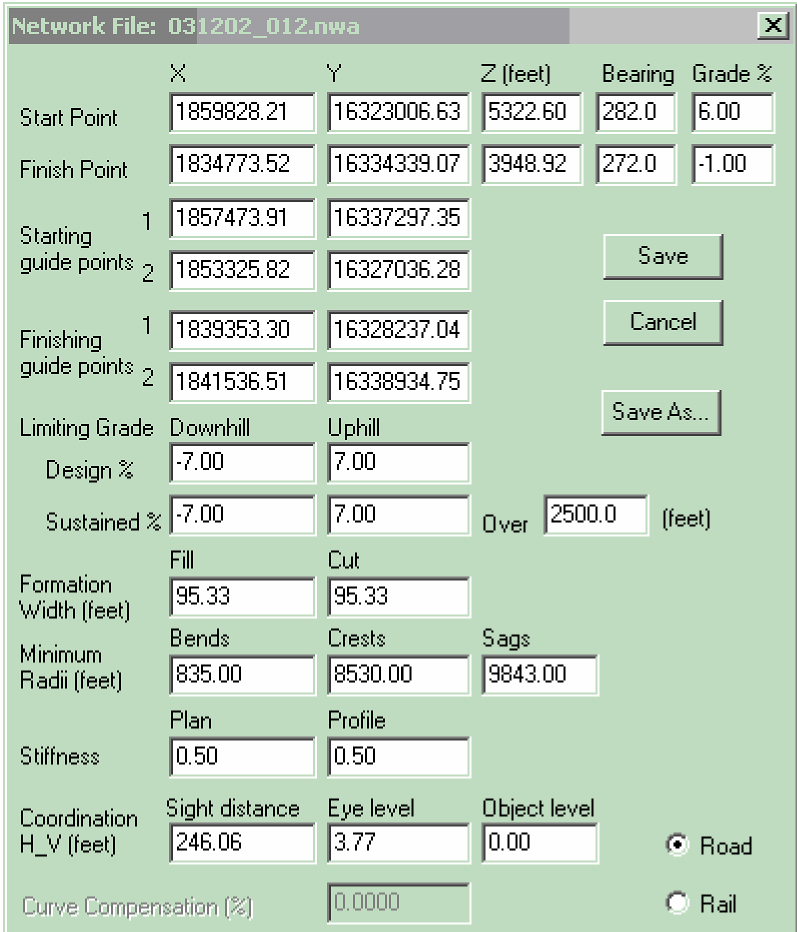

Figure 2: Engineering criteria defined within the Quantm system

What were our baseline highway alternatives?

An initial Quantm run produced a baseline of potential alternatives. The top 11 alternatives from this initial run are shown in figure 3.

The spread of alternatives from this run covers the project area with potential alternatives to the north near the existing highway, to the south around Fish Lake, and across the mountainous central section.

The objective of the initial run was to identify “trends” of alternatives across the defined study area, or corridor opportunities.

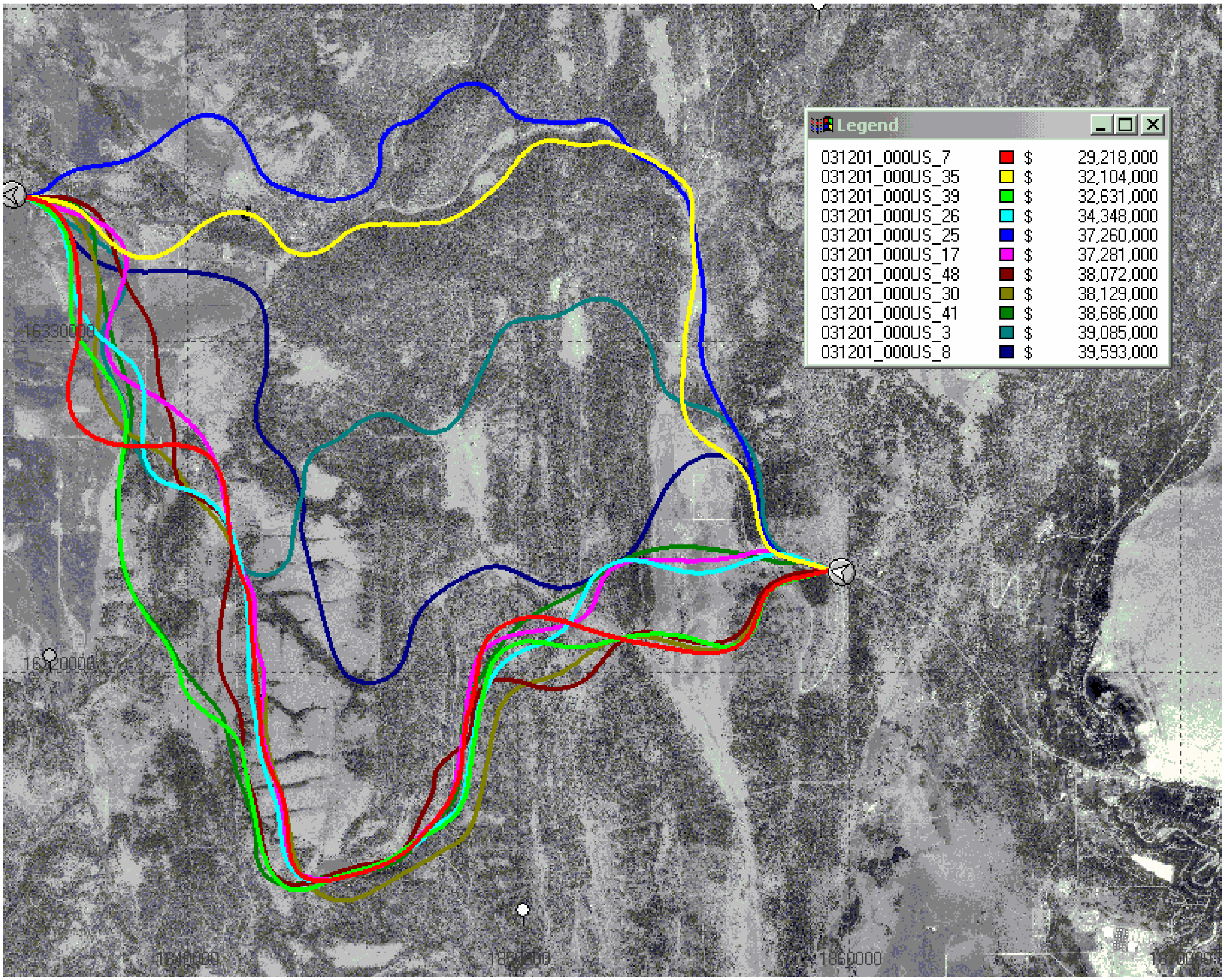

Figure 3: Baseline Using Quantm - No restrictions for two-lane highway

How did we consider environmental concerns in our highway planning?

After establishing a baseline, the next step was to add an increasing number of restrictions. Because of federal law protecting sites of cultural significance, the team determined the project should avoid two well known areas. These areas are the “Little Ski Hill” (a Section 4(f) recreational property) and Packer John’s Cabin (a Section 4(f) historic property). In addition, constraints were set for crossing water bodies. The crossings were: a bridge crossing for Fish Lake, box culverts for Fish Creek, and a bridge(s) for Goose Creek. These avoidance areas and crossing constraints were entered into the Quantm system. Based on these changes, Quantm not only regenerated alternatives that met these new conditions, but considered the added cost of the established crossing structure type to determine which alignments had the lowest cost and met all the criteria. These restrictions (the ‘avoid’ areas plus the crossing constraints) are considered our base set. Figure 4 illustrates the top 10 alternatives developed using this base set.

These highway alternatives still appear across the study area even with the addition of the base constraints. However, the base constraints increases the cost of the alternatives by close to 30 or 40%.

With the base constraints established, more geographically widespread environmental constraints were added to Quantm to narrow the alternatives (wetlands, northern Idaho ground squirrel, cultural areas). With these new considerations, Quantm produced a new set of alternatives. The top 10 alternatives are shown in Figure 5.

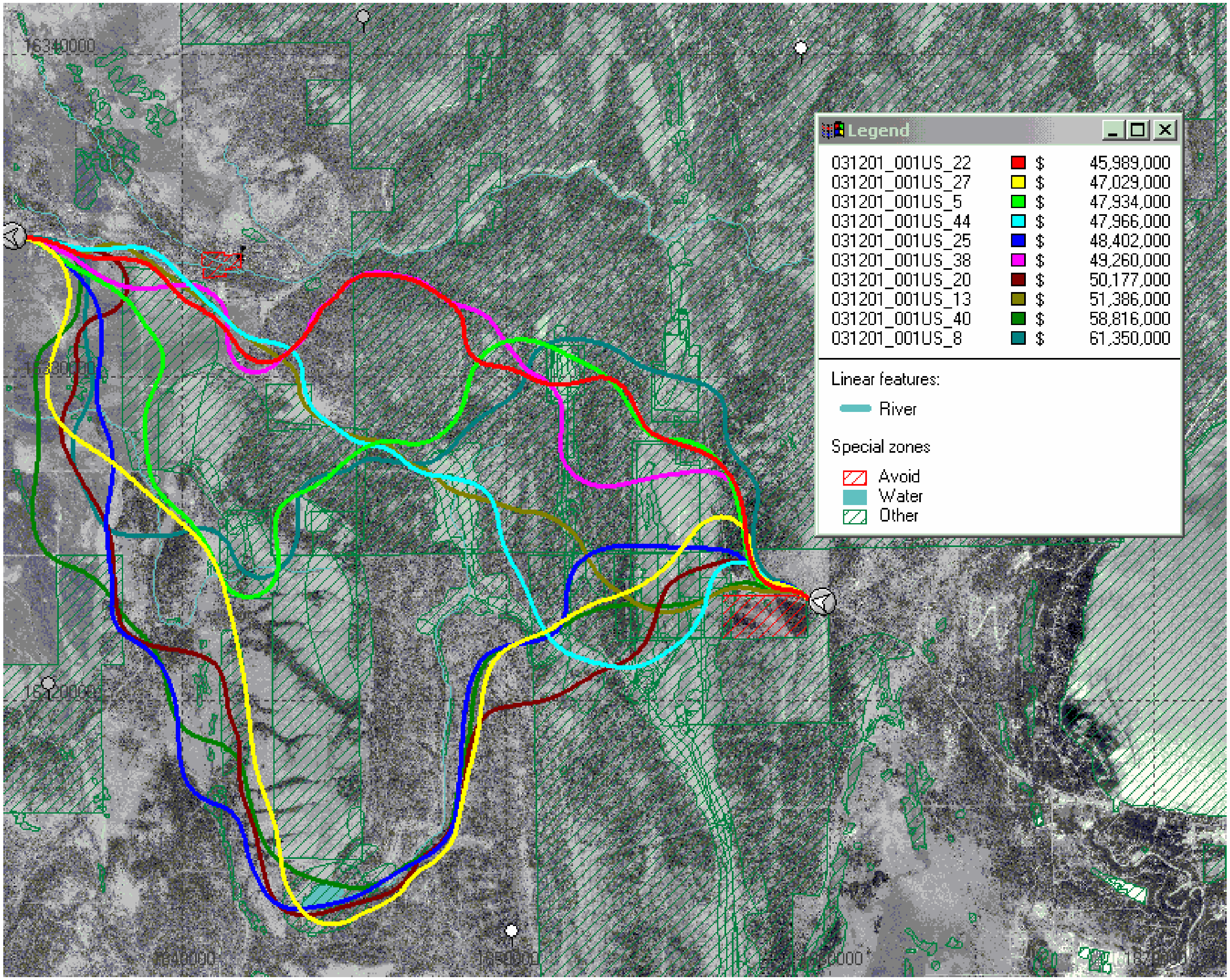

Figure 4: Base constraints with 4(f) properties and structures for water crossings

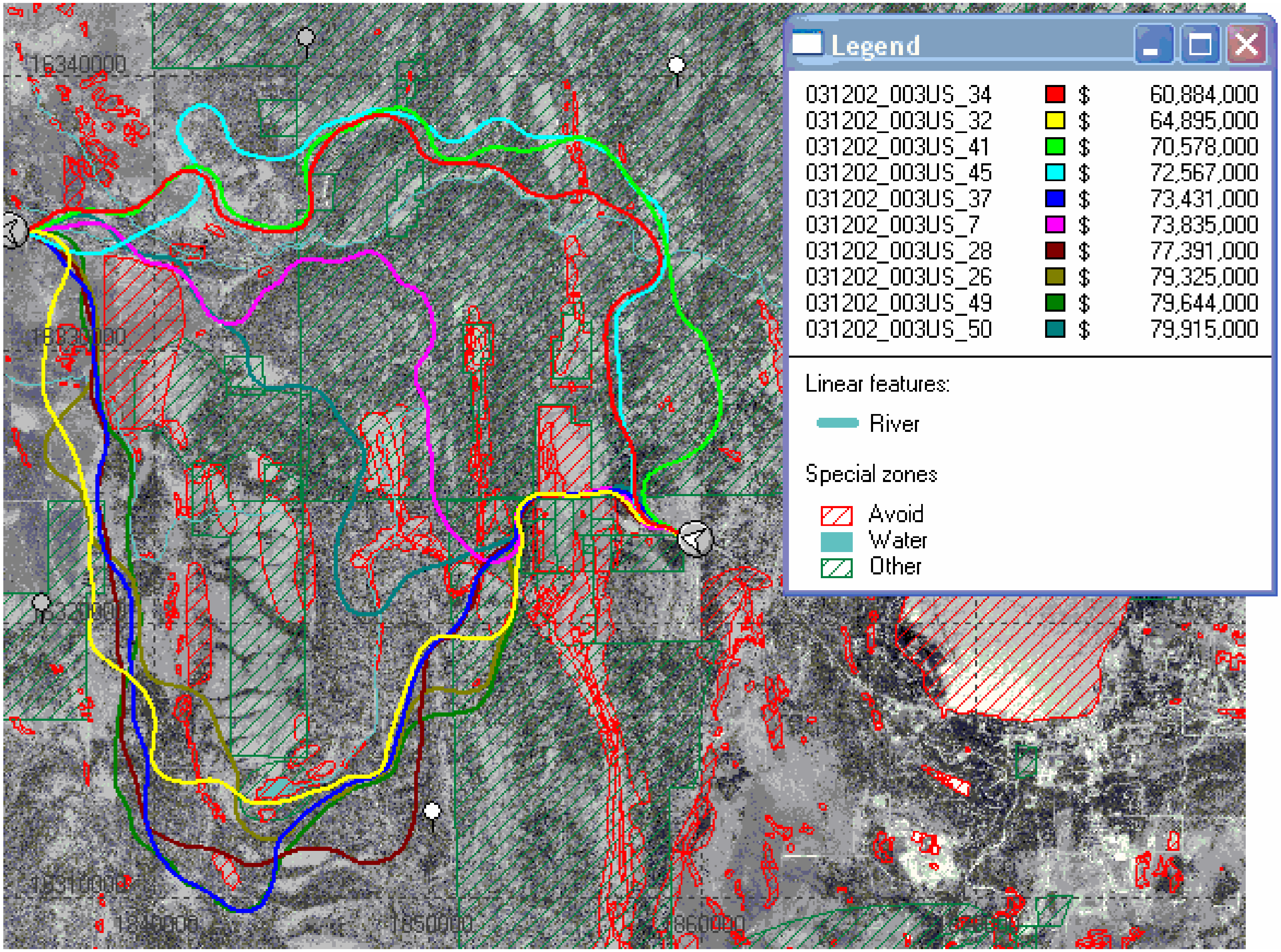

Figure 5: Avoidance of Environmental Constraints Using Quantm - Wetlands, Northern Idaho ground squirrel, and cultural sites

This environmental-constrained Quantm run (figure 5) shows that when all the constraints are considered, most of the alternatives diverge around the study area either to the north or to the south. Most of the alternatives shown in figure 5 extend beyond the intended study area into areas where the available data are not complete. This occurs because the avoid areas are so prevalent when all three sets of constraints are considered together that most alternatives are directed around the available data. This indicates that the project will not be able to avoid all environmentally sensitive features and some encroachment will be necessary. Because of this finding, we chose to define potential corridors without assigning an “avoid” directive to Quantm for wetlands, Northern Idaho ground squirrel habitat, and cultural sites (except the two aforementioned Section 4(f) properties). Instead, these areas were defined as Extra Cost, but the value was set to zero. Using this approach, Quantm generated a report that shows how many acres of each alternative affects for each environmental constraint. The results in turn provide the team the information to make a final decision on what corridors to carry forward into an EA.

The analysis also evaluated the possibility of improving the existing highway rather than building a new alternative. Alternatives returned from Quantm were 2 or 3 times the cost of building a new alternative outside of Goose Creek Canyon.

What happened when we changed the roadway design from 2 to 3 lanes using Quantm?

All the preliminary two-lane alternatives resulted in a sustained grade violation. Initially, the grade parameters were set not to exceed a 7 percent design grade and a 4 percent sustained grade with a two-lane road width. The mountainous terrain in this area makes steep sustained grades inevitable and made it impossible to achieve the 4 percent sustained grade setting. To address the grade issue, we added climbing lanes for trucks and slower traffic for much of the roadway length. To account for this, select runs were repeated using a road width that would accommodate 3 lanes and a sustain grade parameter of 7 percent (the design grade was not changed). Alternatives with 3 lanes from this set of runs are shown in Figure 6.

Several corridors with the 3-lane road width (figure 6) differ from the corridors generated with a 2-lane width (figure 3). However, both sets of design parameters generate alternatives in all the various regions of the project area.

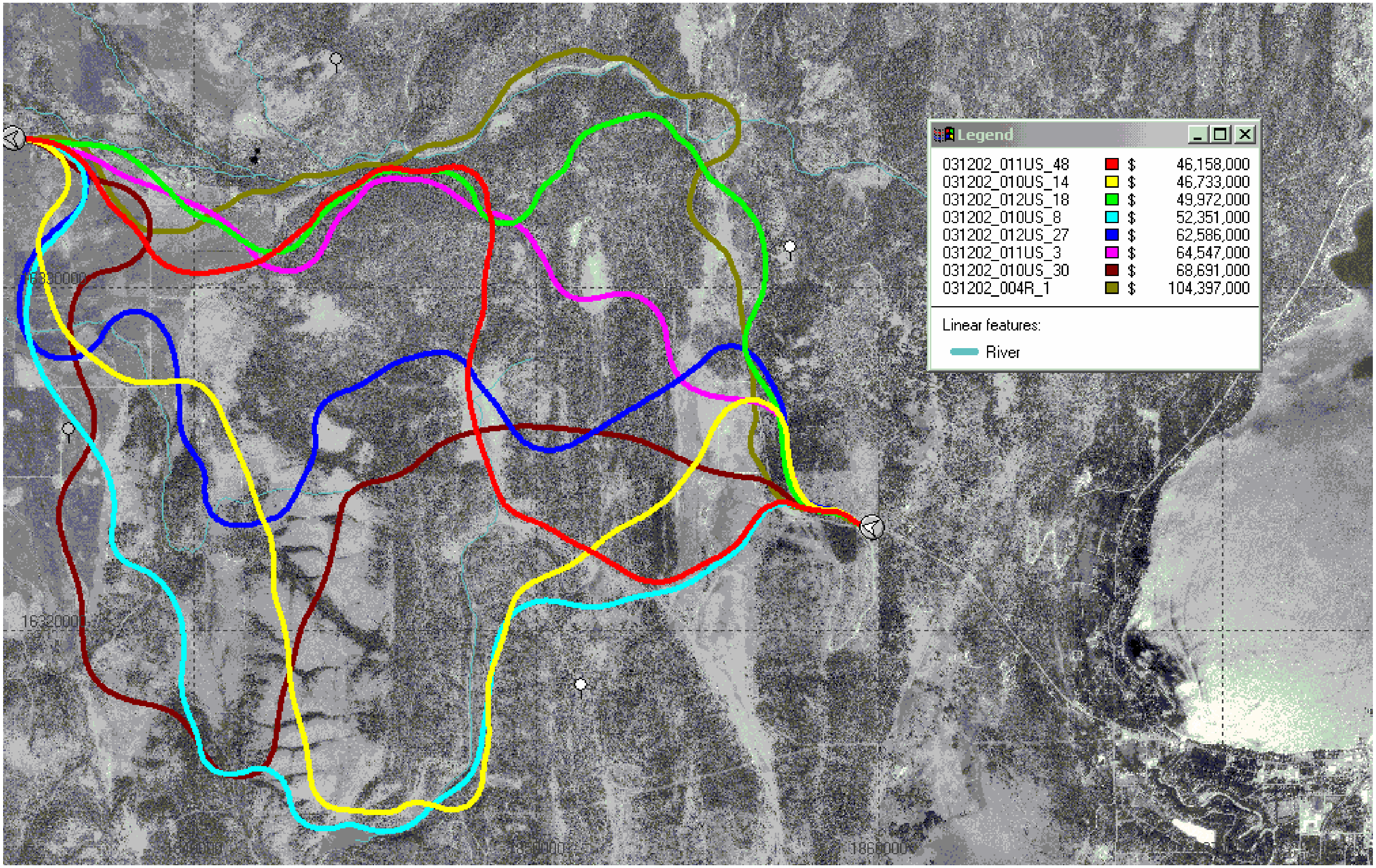

Figure 6: Three lane alternatives to establish preliminary corridors

How did we establish highway corridors?

The eight alternatives shown in figure 6 served as the basis for more Quantm work to define preliminary corridors for further NEPA analysis.

The eight alternatives were run again through the Quantm optimization engine, using a “seeded optimization” to generate a new array of alternatives in close proximity to each of the previous eight alternatives. The footprints of the top-ranking alternatives were mapped to establish eight variable width corridors. The sequential figures 7, 8, and 9 illustrate this process using one of the routes as an example.

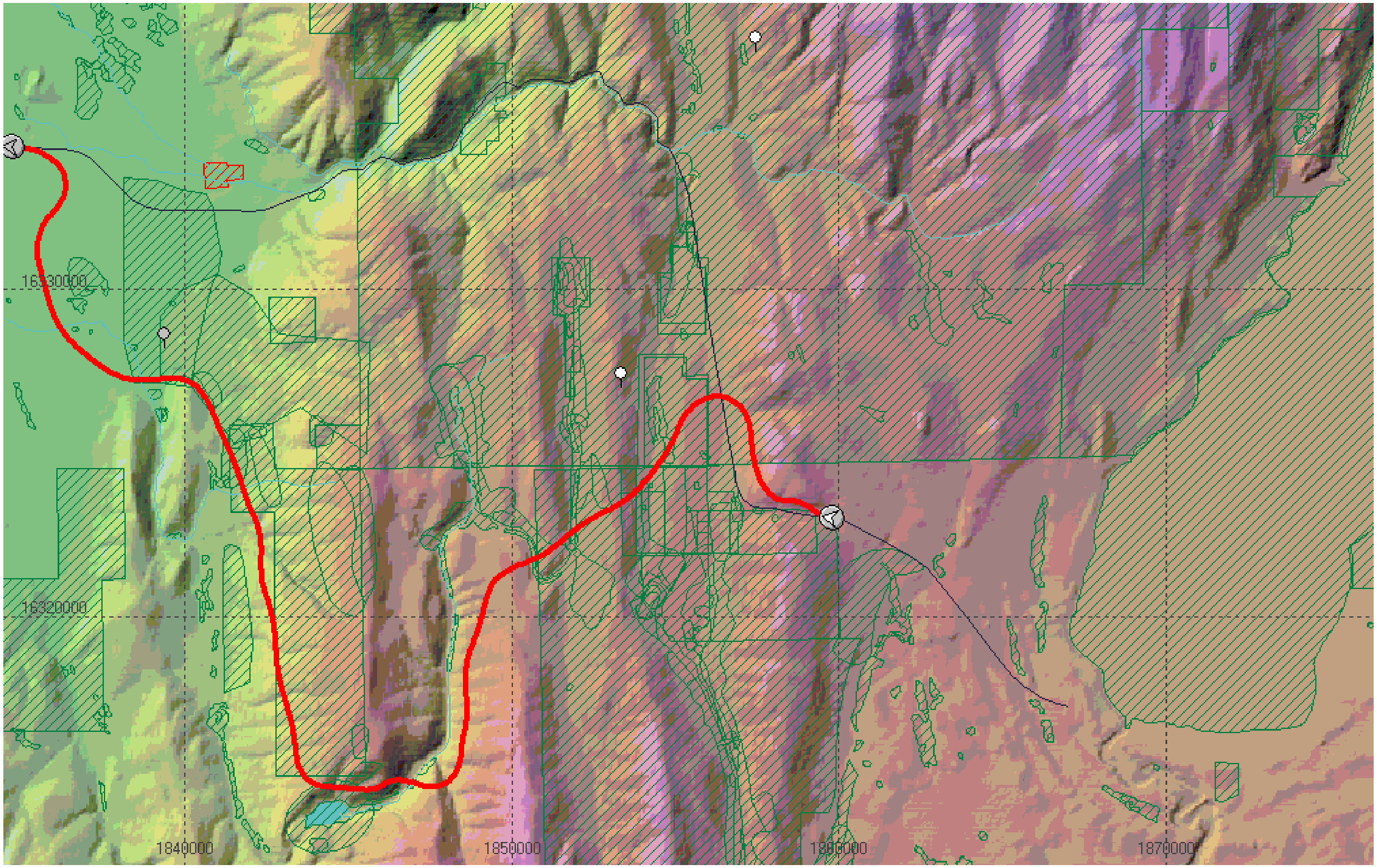

Figure 7 – Seed alternative: this shows an alternative that was sent to Quantm to run a "Total Refinement." The results produce several alternatives from the initial alternative.

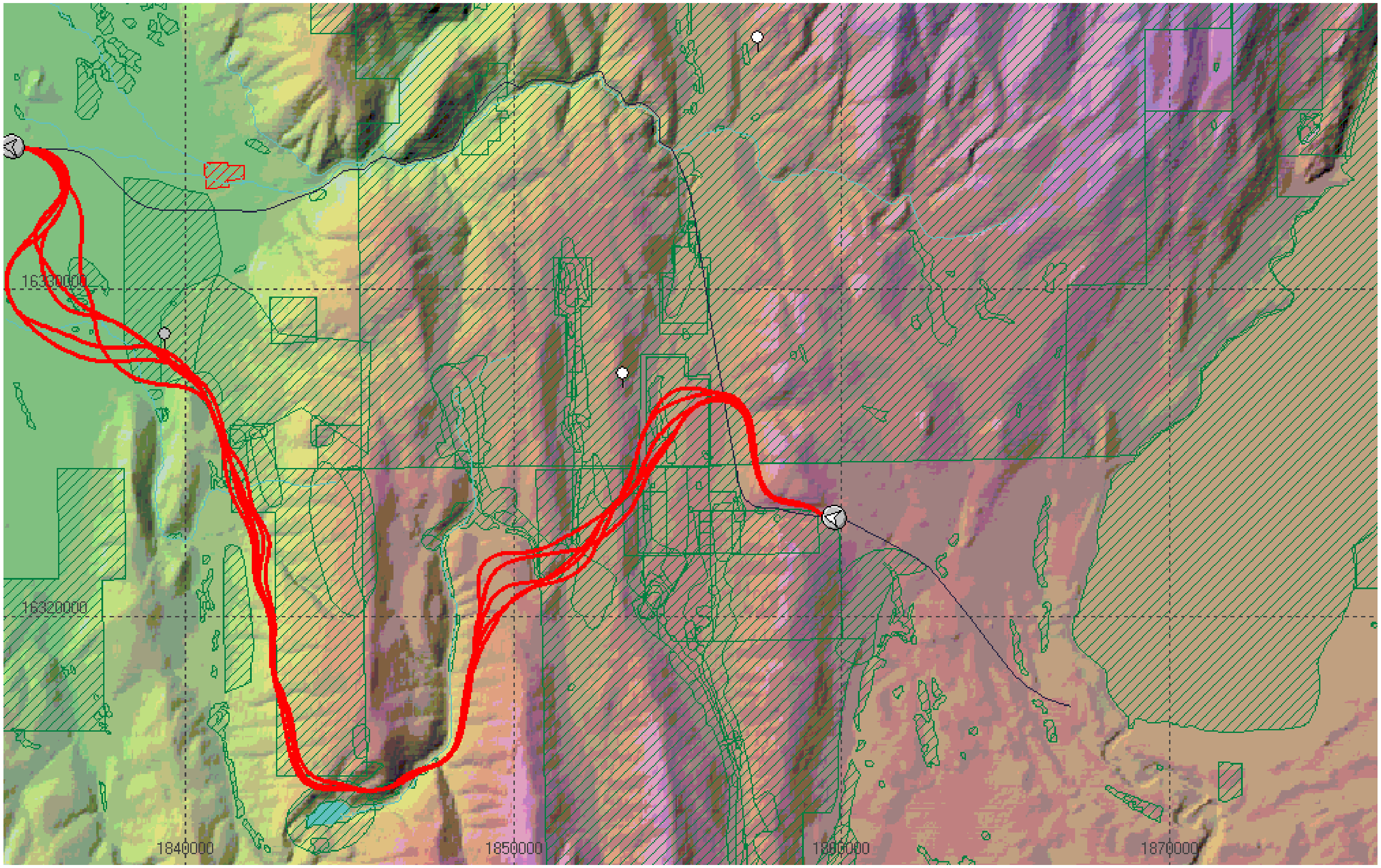

Figure 8 – Top Five Alternatives Used to Define Preliminary Corridors: Using total refinement, produces these top five alternatives . In canyons and narrow passes, the alternatives are close together, and on flatter areas, the alternatives spread out. This indicates that a corridor of varying width is appropriate to define the range of possible alternatives along this corridor

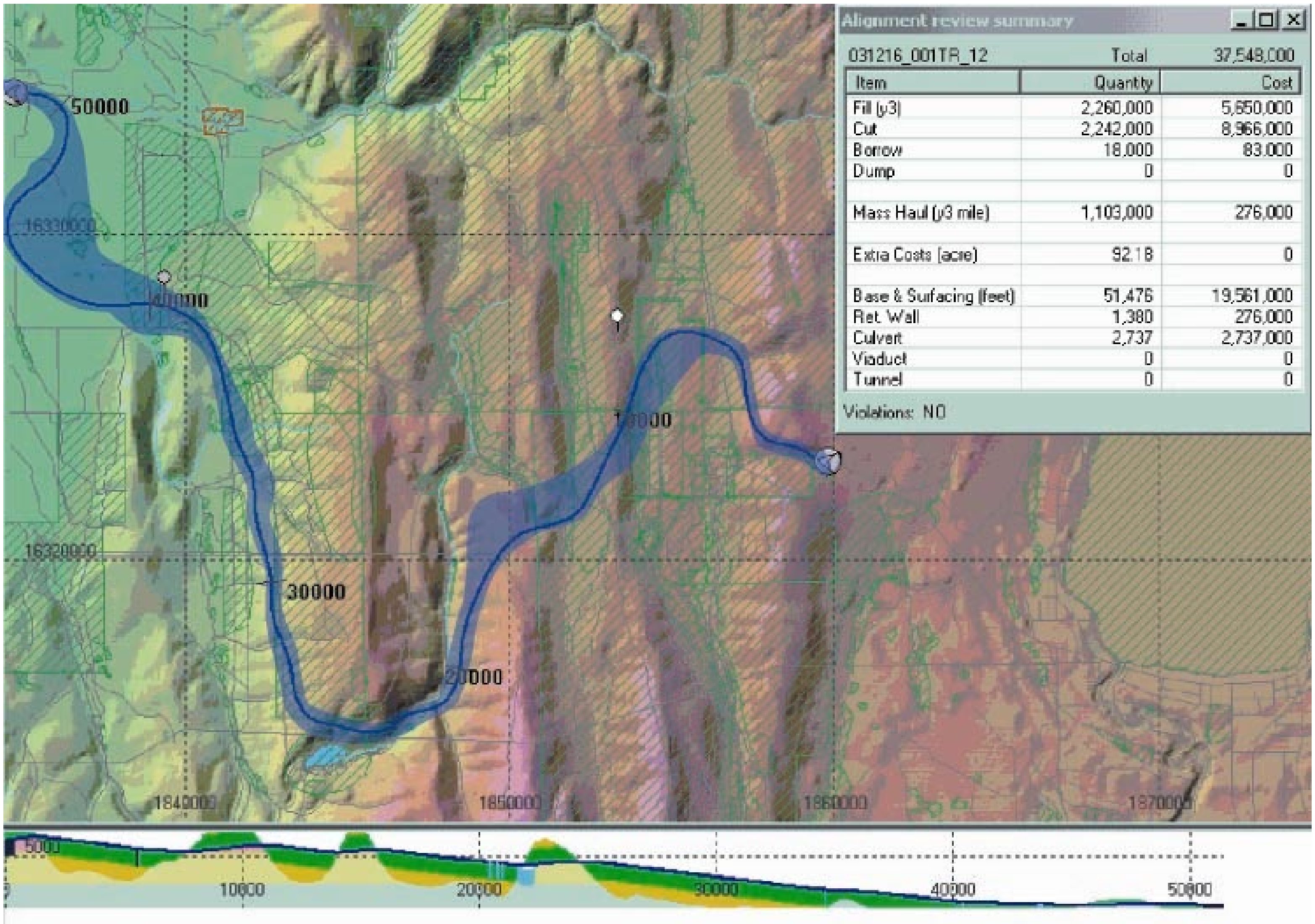

Figure 9 – The final result is a variable-width highway corridor based on the position of the top 5 alternatives from the total refinement

How did we quantify environmental impacts?

Our team defined eight variable width corridors to use in discussions with ITD. The goal of our discussions was to select 2 final corridors for detailed analysis in the NEPA EA.

Table 2 presents the environmental data from the eight alternatives . Quantm generated these data for the individual alternatives.

Table 2 also provides an overview of the acreage that each alternative would affect for different environmental factors. Adjustments of each alternative within the corridors may be possible to reduce these values.

Table 2
Environmental Data for Preliminary Alternatives
Acres of Land Types Overlain by Each Alternative

	Quantm ID no.	Wetland (acres)	Squirrel Habitat (acres)	Eagle Forage Habitat (acres)	Cultural Sites (acres)	Private[a] Land (acres)	Public Land (acres)	Total[b] (acres)
Alternative 1	000TR_5	6.2	49.1	0.0	28.9	105	69	174
Alternative 2	001TR_12	3.8	22.7	5.1	7.1	201	35	236
Alternative 3	002TR_6	3.1	10.6	0.0	5.1	89	81	170
Alternative 4	003TR_20	9.7	21.1	13.0	13.6	227	0	227
Alternative 5	004TR_7	5.1	37.4	0.0	13.6	98	112	210
Alternative 6	005TR_9	2.0	21.8	0.0	13.6	56	109	165
Alternative 7	006TR_8	5.6	37.5	0.0	10.9	144	101	245
Alternative 8	007R_16	9.4	13.0	0.0	64.3	25	161	186

a Private land acres are the difference between total acres and public acres.

b Total acres are based on a 200-foot ROW corridor along each alignment.

How did our approach address the challenges of the highway environmental process?

Using the approach outlined in this paper, the project team addressed the challenges identified for this project. These challenges are common to all studies that have to demonstrate compliance with NEPA. The points below summarize this approach and our results.

1. How to deal with previously studied highway alternatives?

With the Quantm system, we could simply import the alignments developed in previous studies into the system where they could be viewed in the same model as the Quantm derived alignments. Being able to view all the alternatives in the same model, allowed us to ensure that comparisons - on location, impact on environment, cost and compliance with engineering criteria – occurred on an equal basis.

2. How to evaluate the existing highway upgrade comparably to new highway alternatives?

The existing Goose Creek Canyon route was entered into the Quantm system . Using the Quantm optimization engine with a “seeded optimization”, we generated an array of alternatives. These alternatives provided cost and whether the alternatives to upgrade the existing route met the current design criteria for. Quantm clearly demonstrated that it was cost prohibitive to attempt to comply with current design standards by modifying the existing route within the canyon.

3. How to consider other highway alternatives with dollar and time limitations?

Once the initial project database was created within the Quantm system (during the training program), the team could quickly change the environmental and engineering criteria and generate new alignments that the team could review within days. This shows that you can investigate alternative scenarios comprehensively without delaying the project.

Because Quantm allows you to focus the area of investigation, use the refinement capability and/or designate no-go zones, it is no longer labor and cost intensive to consider new alternatives that may be suggested by the project stakeholders.

4. How to gain the trust and confidence of the public that your work is objective?

In previous projects, many decisions on where to locate an alignment would be based on the instinct and skill of the planner. While the planner may have sound judgments, it was impossible to prove the work was objective. Also, due to the time required to create new engineering alignments to address new environmental criteria or suggestions from stakeholders, these requests would be resisted because of the time and cost impact.

Using the Quantm system, the team was able to demonstrate a comprehensive investigation of alternatives, both across the whole terrain model and in focused areas. The system highlights where constraints cannot be met and presents the alignment and how changes affect cost in an unbiased way.

5. How to gain the trust and effectively work with resource agencies?

Entranco takes a collaborative approach to working with resource agencies, an approach that is enhanced by applying the Quantm system. The system allows the team to quickly consider new environmental criteria or investigate alternative alignments. By generating new alternatives rapidly, we demonstrate to the agencies that we have integrated their views into the study. Using Quantm also provides clear, objective evidence as to where it is not possible to avoid particular zones due to reasons such as the impact on other zones, inability to meet safe design criteria, or non-viable cost implications.

6. How to obtain concurrence on a screening process with stakeholders?

Our plan for this project was to collaborate with stakeholders in workshops using the Quantm system. The workshops would demonstrate how the system attributes can objectively evaluate alternatives and would allow us to gain the stakeholders' confidence and concurrence on the screening process.

7. How to agree on how much data are enough to make a screening decision?

This challenge is particularly relevant for our work with resource agencies. Our plan for this project was to hold screening workshops to demonstrate how you can use the attributes of the Quantm system to objectively evaluate alternatives. As part of this collaboration, we would discuss the data needs and agree on the environmental data requirements to make screening decisions. Our unique approach of using the Quantm system to define highway corridors was intended to limit the areas for intensive environmental field work and still provide a product that would comply with NEPA.

8. How to advance the project in light of politics, policy changes, and turnover of team members?

Planning project teams need two key capabilities: flexibility to respond to emerging or changing criteria, which may arise from the department, politicians, resource agencies or the public; and the ability to document the process undertaken to select 'preferred corridors and alternatives' to ensure the project momentum can be maintained as team members change, and stand up to rigorous questioning by stakeholders.

Where should we go from here?

Highway corridors have been defined to achieve the purpose and need of this project based on the Quantm engineering and environmental analysis of alternatives.

The next steps in the planning process were not performed due to a shift in ITD funding priorities. The wealth of engineering, cost, and environmental information provided by this Quantm effort helped ITD make the decision to not pursue the project at this time.

If the project had proceeded~~However~~ as planned, the next steps ~~we planned~~ for completing this project included:

- Workshop briefings with resource agencies to:
  - Agree on the corridor establishment process
  - Agree, based on environmental data (table 1), on corridors to study in detail in the NEPA process
  - Agree on the type and amount of data needed for these corridors to screen and select an alternative for corridor preservation
- Publish a newsletter which described the project status
- Conduct public open houses and briefings to interested stakeholders to present results
- Initiate Phase 2 of the Goose Creek Grade Bypass Project and conduct field-based environmental inventories
- Provide more specific engineering information
- Use Quantm to integrate additional criteria emerging from resource agency workshops and public open houses and further define alternatives to optimize engineering benefits and minimize impacts and costs.
- Prepare NEPA documentation for public review and final decisions on a preferred highway alternative.

We have implemented a highway corridor planning / environmental / engineering process to establish highway corridors and select alternatives that will comply with NEPA regulations. This process can address many of the challenges found in highway environmental process by being objective, comprehensive, cost-effective, and quicker than conventional methods. We believe this process is ~~w~~worth repeating in Idaho.